

08200002AA

28

# CLAIMS

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is as follows:

- 1 1. A mobile apparatus comprising:  
2 at least one first sensor for detecting an  
3 obstacle in at least the mobility path of said  
4 mobile apparatus and providing first data,  
5 at least one second sensor for determining the  
6 stability of said mobile apparatus and providing  
7 second data,  
8 at least one active joint, and  
9 an algorithm for integrating perception in  
10 accordance with at least one of said first data and  
11 said second data with action of said joint in  
12 performing a cyclic stride and/or adjustment of said  
13 cyclic stride to avoid an obstacle.
- 1 2. A mobile apparatus as recited in claim 1 wherein  
2 said first sensor is a distal sensor and records  
3 visual sensory stimuli using at least one of the  
4 methods of optic flow, stereopsis, and depth from  
5 elevation.
- 1 3. A mobile apparatus as recited in claim 2 wherein  
2 said distal sensor is at least one of a camera, a  
3 laser range finder, ultrasonic range finder, radar,  
4 or at least two stereo cameras.
- 1 4. A mobile apparatus as recited in claim 1  
2 additionally comprising at least one 'foot' wherein  
3 said at least one second sensor for determining the

08200002AA

29

4 stability of the apparatus is located on said  
5 'foot'.

1 5. A mobile apparatus as recited in claim 4 wherein  
2 said second sensor is at least one of a tactile  
3 sensor, pressure sensor, or vestibular sensor, or  
4 multiple second sensors comprising a combination of  
5 tactile, pressure, and/or vestibular sensors can be  
6 used.

1 6. A mobile apparatus as recited in claim 1 wherein  
2 said algorithm utilizes:  
3 an autonomous system of limit cycle oscillators  
4 that generate the necessary pattern for limb  
5 movement,  
6 a pseudo-cerebellum, and  
7 a reflex system that recognizes instability of  
8 said mobile apparatus using said at least one first  
9 or second sensor for learning what constitutes an  
10 obstacle.

1 7. A mobile apparatus as recited in claim 6 wherein  
2 said first sensor is at least one of a camera,  
3 a laser range finder, ultrasonic range finder,  
4 microwave, ultrasound, radar, or at least two stereo  
5 cameras, and  
6 said second sensor is at least one of a tactile  
7 sensor, pressure sensor, or vestibular sensor, or in  
8 the event of multiple second sensors, a combination  
9 of tactile, pressure, and/or vestibular sensors can  
10 be used.

1 8. A mobile apparatus as recited in claim 7 wherein  
2 said autonomous system is a system capable of

08200002AA

30

3 generating a periodic gate.

1 9. A mobile apparatus as recited in claim 7 wherein  
2 said system is capable of generating a periodic gate  
3 is a CPG.

1 10. A mobile apparatus as recited in claim 7  
2 wherein the pseudo-cerebellum performs the functions  
3 of comparison, adaptive gain, and novelty  
4 determination based on visual perceptual elements  
5 recognized by said at least one first sensor.

1 11. A mobile apparatus as recited in claim 10  
2 wherein the pseudo-cerebellum performs the  
3 additional function of prediction based on other  
4 sensory stimuli and an efference copy.

1 12. A mobile apparatus as recited in claim 1  
2 wherein said algorithm is located on a compact  
3 customized neuromorphic chip.

1 13. A method for determining gait adjustments in a  
2 mobile apparatus thereby allowing said mobile  
3 apparatus to bypass an obstacle including;  
4 receiving raw visual data,  
5 determining what data within said raw data set  
6 is novel based on predictions,  
7 determining if an obstacle is in the mobility  
8 path of said mobile apparatus by associating past  
9 patterns recorded by said mobile apparatus with past  
10 reflexes of said mobile apparatus using a  
11 sensorimotor map,  
12 sending determined information to a central  
13 pattern generator (CPG) to calculate and dictate

08200002AA

31

14 motor commands and resultant movement of said mobile  
15 apparatus,  
16 sending an error signal back to the  
17 sensorimotor map in the event that instability is  
18 detected by sensors on said mobile apparatus as a  
19 result of an obstacle, and  
20 learning to associate visual data with emerging  
21 obstacles in response to data acquired by at least  
22 one first sensor and at least one second sensor.

1 14. A method as recited in claim 13 wherein said  
2 first sensor is a distal sensor and records visual  
3 sensory stimuli using at least one of the methods of  
4 optic flow, stereopsis, depth from elevation and is  
5 at least one of a camera, a laser range finder, an  
6 ultrasonic range finder, radar, microwave,  
7 ultrasound, or at least two stereo cameras.

1 15. A method as recited in claim 13 wherein said  
2 second sensor is at least one of a tactile sensor,  
3 pressure sensor, or vestibular sensor.

1 16. A method as recited in claim 13 wherein said  
2 raw data includes geometric information only  
3 including one or more of the following visual cues:  
4 optic flow,  
5 stereopsis, and  
6 depth from elevation.

1 17. A method as recited in claim 13 wherein said raw  
2 data includes non-geometric information including at  
3 least one of the following visual cues indicating  
4 the quality of a surface:  
5 surface texture,

08200002AA

32

6 surface color,  
7 surface pattern, and  
8 specular reflection,  
9 wherein utility functions for multiple surfaces can  
10 be determined from said at least one non-geometric  
11 visual cue.

1 18. A method as recited in claim 17 wherein said raw  
2 data further includes geometric information derived  
3 from at least one of the following geometric visual  
4 cues:

5 optic flow,  
6 stereopsis, and  
7 depth from elevation.

1 19. A method as recited in claim 13 wherein said  
2 error signal is triggered by at least one non-distal  
3 sensor located on a 'foot' of said mobile apparatus,  
4 a stumble reflex is engaged.

1 20. A method as recited in claim 19 wherein  
2 said error signal is triggered when the foot is  
3 mobile in the upward direction and engaging said  
4 stumble reflex, wherein the stride of the mobile  
5 apparatus will be lengthened during the encounter to  
6 maneuver past the obstacle, but will learn to  
7 shorten the stride to secure foot placement directly  
8 before the obstacle and bring the foot to a greater  
9 height upon passing an obstacle on a similar future  
10 encounter, and  
11 said error signal is triggered when the foot is  
12 mobile in the downward direction and engaging said  
13 stumble reflex, wherein the stride is prematurely  
14 terminated to rest said 'foot' on said obstacle

08200002AA

33

15 during the encounter to maneuver past the obstacle,  
16 but will learn to lengthen said stride on a similar  
17 future encounter with a similar obstacle in order to  
18 clear the obstacle fully in one stride.